

Symposium on Metallic Materials for Service at Temperatures Above 1600 F

Presented at the
FIFTY-EIGHTH ANNUAL MEETING
AMERICAN SOCIETY FOR TESTING MATERIALS
Atlantic City, N. J., June 30, 1955



ASTM Special Technical Publication No. 174

Published by the
AMERICAN SOCIETY FOR TESTING MATERIALS
1916 Race St., Philadelphia 3, Pa.

Symposium on Metallic Materials for Service at Temperatures Above 1600 F

Presented at the
FIFTY-EIGHTH ANNUAL MEETING
AMERICAN SOCIETY FOR TESTING MATERIALS
Atlantic City, N. J., June 30, 1955



Reg. U.S. Pat. Off.

ASTM Special Technical Publication No. 174

Price: \$3.50; to Members, \$2.65.

Published by the
AMERICAN SOCIETY FOR TESTING MATERIALS
1916 Race St., Philadelphia 3, Pa.

COPYRIGHT, 1956
BY THE
AMERICAN SOCIETY FOR TESTING MATERIALS

Printed in Baltimore, Md.
February, 1956

FOREWORD

The papers and discussions in this Symposium on Metallic Materials for Service at Temperatures Above 1600 F were presented at the Twenty-fourth and Twenty-seventh Sessions of the Fifty-eighth Annual Meeting of the American Society for Testing Materials, held in Atlantic City, N. J., June 30, 1955. This Symposium was sponsored by the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals. The paper by Thomas A. Hunter entitled Thermal Shock Testing of High-Temperature Metallic Materials was presented at the Twenty-ninth Session but is included in this publication since it is pertinent to and rounds out the rest of the Symposium.

Mr. V. N. Krivobok, International Nickel Co., New York, N. Y., acted as Symposium Chairman. Mr. E. N. Skinner, International Nickel Co., New York, N. Y., and Mr. C. T. Evans, Jr., Universal-Cyclops Steel Corp., Bridgeville, Pa., presided over the twenty-fourth session while Mr. V. N. Krivobok and Mr. A. W. F. Green, General Motors Corp., Indianapolis, Ind., acted as Co-chairmen for the twenty-seventh session. Mr. F. L. LaQue, International Nickel Co., New York, N. Y., acting in the capacity of coordinator contributed much towards the success of this Symposium.

Special mention should be made of the Symposium on Basic Effects of Environment on the Strength Scaling and Embrittlement of Metals at High Temperatures which was presented at the Cincinnati Spring Meeting of the Society, February 2, 1955, and was published as *ASTM Special Technical Publication No. 171*. These papers are listed below:

Introduction—Evan A. Davis.

The Role of Thin Surface Films in the Deformation of Metal Monocrystals—John J. Gilman.

Structure of Oxides Formed on High-Temperature Alloys at 1500 F—John F. Radavich.

Effect of Strain on the Oxidation of Nickel-Chromium Heater Alloys—Earl A. Gulbransen and Kenneth F. Andrew.

An Investigation of Intergranular Oxidation in Type 310 Stainless Steel—R. E. Keith, C. A. Siebert and M. J. Sinnott.

The Properties of Oxidation-Resistant Scales Formed on Molybdenum-Base Alloys at Elevated Temperatures—M. Gleiser, W. L. Larsen, R. Speiser, and J. W. Spretnak.

Oxidation at Elevated Temperatures—John F. Radavich.

NOTE.—The Society is not responsible, as a body, for the statements
and opinions advanced in this publication.

CONTENTS

| | PAGE |
|---|------|
| Introduction—V. N. Krivobok | 1 |
| Some Sheet and Bucket Materials for Jet-Engine Application at 1600 F and Higher— J. P. Denny, L. P. Jahnke, E. S. Jones, and F. C. Robertshaw, Jr..... | 3 |
| Influence of Boron on Cast Cobalt-Base S-816 Alloy—W. E. Blatz, E. E. Reynolds, and W. W. Dyrkacz..... | 16 |
| Discussion | 24 |
| Effect of Heat Treatment and Structure Upon Creep Properties of Nimonic Alloys Between 750 and 950 C—W. Betteridge and R. A. Smith..... | 29 |
| Stress-Rupture Properties of Inconel 700 and Correlation on the Basis of Several Time-Temperature Parameters—S. S. Manson and G. Succop..... | 40 |
| Chromium-Nickel Alloys for High-Temperature Applications—Albert G. Bucklin and Nicholas J. Grant..... | 47 |
| Discussion | 56 |
| Effect of Rare Earth Additions on the High-Temperature Properties of a Cobalt- Base Alloy—J. E. Breen and J. R. Lane..... | 57 |
| Discussion | 66 |
| Creep, Rupture, and Notch Sensitivity Properties of S-816 Alloy Up to 1650 F Under Fatigue and Static Stress—F. Vitovec and B. J. Lazan..... | 69 |
| Discussion | 89 |
| Titanium-Carbide-Base Cermets for High-Temperature Service—K. Pfaffinger, H. Blumenthal, and F. W. Glaser..... | 90 |
| Discussion | 99 |
| Titanium-Carbide Products Produced by the Infiltration Technique—Leonard P. Skolnick and Claus G. Goetzel..... | 103 |
| Discussion | 110 |
| High-Temperature Properties of Molybdenum-Rich Alloy Compositions Made by Powder Metallurgy Methods—W. L. Bruckart and R. I. Jaffee..... | 111 |
| Tension and Torsion Tests on Nimonic Alloys at High Temperatures—E. D. Ward and W. G. Tallis..... | 135 |
| Thermal Fatigue Testing of Sheet Metal—H. E. Lardge..... | 146 |
| Discussion | 160 |
| Thermal Shock Testing of High-Temperature Metallic Materials—Thomas A. Hunter..... | 164 |
| Discussion | 180 |
| The Development of Zirconium-Rich Protective Coatings and Brazing Materials for Heat Resisting Alloys—A. Blainey..... | 183 |

THIS PUBLICATION is one of many issued by the American Society for Testing Materials in connection with its work of promoting knowledge of the properties of materials and developing standard specifications and tests for materials. Much of the data result from the voluntary contributions of many of the country's leading technical authorities from industry, scientific agencies, and government.

Over the years the Society has published many technical symposiums, reports, and special books. These may consist of a series of technical papers, reports by the ASTM technical committees, or compilations of data developed in special Society groups with many organizations cooperating. A list of ASTM publications and information on the work of the Society will be furnished on request.